TECHNOLOGY SAFETY DATA SHEETS: THE U.S. DEPARTMENT OF ENERGY'S INNOVATIVE EFFORTS TO MITIGATE OR ELIMINATE HAZARDS DURING DESIGN AND TO INFORM WORKERS ABOUT THE RISKS OF NEW TECHNOLOGIES

Bruce E. Lippy
Operating Engineers National Hazmat Program

ABSTRACT

Technology Safety Data Sheets (TSDSs) are novel instruments for communicating safety and health information about a new environmental remediation technology. As originally conceived, TSDSs would be used by workers who operate and maintain the technology, safety and health professionals charged with protecting personnel on hazardous waste sites, and regulators who must write permits for technologies on state Superfund sites. The instrument uses the familiarity of MSDSs to impart critical information about the risks to workers posed by new technologies. The Operating Engineers National Hazmat Program (OENHP) has created TSDSs for over 60 technologies ranging from robotic asbestos strippers to carbon dioxide floor blasting systems. Other organizations including OSHA, the Navy, and Indiana University of Pennsylvania have created TSDSs. The U.S. Department of Energy (DOE) promoted the concept with the most creative and comprehensive policy initiatives. All of the technologies that have been funded by the DOE Office of Science and Technology will ultimately have TSDSs created before the technology is deployed. This paper presents the history of this informational tool, how it can be used to protect workers, how it should be formatted, and what future policy initiatives and research are needed.

BACKGROUND

The U.S. Department of Energy (DOE) Office of Science and Technology (OST) has funded the development of hundreds of technologies that are needed for the unprecedented and complex cleanup of the legacy wastes from the U.S. nuclear weapons program. Potential costs savings from these new technologies are enormous and the technologies are generally more protective of workers, as well. One study indicated that 71 percent of the new OST technologies deployed for the first time in 1999 had a moderate-to-high potential for reducing occupational safety and health exposures compared to the older, baseline technologies. (1) Unfortunately, the OST program suffered a serious accident at its Portsmouth plant in August, 2000 when an explosion occurred during the testing of a new in situ technology and a worker was badly burned. (2) The process that exploded was theoretically safer than the older, baseline technology it was replacing. Rather than pulling chemically-contaminated soils and ground water to the surface to be treated, this technology was designed to destroy chemicals such as trichloroethylene underground through reaction with chemicals injected into the soil. The explosion was a stark reminder that, in regards to safety, the devil is in the details. Greater focus on safety from the earliest stages of design can produce a much more robust and productive technology.

Dr. Carolyn Huntoon, the Assistant Secretary for Environmental Management (EM) of the Department of Energy, has championed the protection of the 120,000 workers who are cleaning up the weapons complex. To that end, she has embraced all of the April 2000 recommendations of an independent advisory board for improving the integration of safety and health into the design and deployment of new technologies. One of the key recommendations of the board was for OST to develop Technology Safety Data Sheets (TSDSs) for all technologies supported by DOE funds. The board recommended that the documents should be created for the mid-stage review, i.e., after the technology is approximately halfway to deployment. (3) The specific format for the document was not stipulated but an example from the Operating Engineers National Hazmat Program was included in the report. The policy objective was to have a separate document that carried only safety and health information and could be used for several key purposes.

The DOE has done more than any other federal agency in the development of TSDSs but there are other organizations exploring the concept. The U.S. Navy has created approximately 20 TSDSs for maintenance equipment such as large trash compactors and paint spray technologies. The U.S. Occupational Safety and Health Administration (OSHA) has created several generic examples for broad classes of technologies found on hazardous waste sites, like thermal desorption and soil washing technologies. OSHA, as a regulatory agency, cannot take a technology-specific focus similar to that of the DOE, without appearing to be pursuing an enforcement action. Finally, the U.S. Department of Defense has created several TSDSs through a contract with the National Environmental Education and Training Center of the Indiana University of Pennsylvania.

HISTORY OF CONCEPTUAL DEVELOPMENT

The concept was created by Matthew Fitzgerald, Dr. P.H., CIH, CSP while working on a contract with the Department of Energy's Office of Environment, Safety, and Health in 1994. The concept was presented to safety and health experts at DOE and the National Institute of Environmental Health Sciences (a part of the U.S. Department of Health and Human Services) and received sufficient interest from key actors at each organization to pursue creating a guidance document. On March 23-24, 1995, a National Technical Workshop was held in Washington, D.C. and included representatives from DOE, NIEHS, OSHA, U.S. EPA, the National Institute for Occupational Safety and Health, the U.S. Department of Defense, the Army Corps of Engineers, labor unions, universities, and private firms. The sixty participants produced a set of recommendations and agreed to gather again to produce a guidance document. On November 30th and December1st, 1995 the experts met and reached consensus on effective guidance. In October 1996, after distribution and revision of a draft, the final guidance document was issued with the first example of a Technology Safety Data Sheet. (4) This document is available at: http://www.iuoeiettc.org.

A follow-up National Technical Workshop was held in Miami October 14-16, 1998 to develop more detailed guidance for considering safety and health in the design of remediation technologies. Forty-one national experts, including several from state environmental regulatory agencies, produced a draft guidance document that was revised once and issued as interim final guidelines on March 31, 1999. This document, "New Environmental Remediation Technologies: Guidance Criteria for Safety and Health" provided specific recommendations for how the key stakeholders, such as the EPA and DOE, should implement the guidance contained in the document. There was much more comprehensive guidance for creating Technology Safety Data Sheets as well. This document can be obtained at the Operating Engineers National Hazmat Program's website at: http://www.iuoeiettc.org. The guidance was called "interim" until it can be pilot tested to ensure it is reasonable and valuable. Testing is ongoing.

A recent National Technical Workshop sponsored by DOE in October 2000 examined the costs of ignoring health and safety in the design of innovative remediation technologies. (5) A separate break-out group at the workshop considered the status of TSDS and came to consensus on the following points:

- The document should be created primarily for workers;
- TSDSs can assist in hazard assessments but should not take the place of more formal assessments;
- All hazards should be identified and rated as either low, medium, or high risk;
- TSDSs should identify hazards in each phase of the technology from construction, through operation and maintenance, to final decontamination and dismantling;
- TSDSs should be kept in close proximity to the technology for easy access by workers;
- TSDSs should be used as tools for training workers; and
- Creating a TSDS can help a technology developer comply with the European requirements for CE Marking, as well as the new ANSI recommendations for machine tools found in ANSI B11.TR3:2000.

The EPA/Labor Superfund Task Force, an ad hoc group comprised of key federal agencies responsible for hazardous waste clean up and the labor unions responsible for conducting the work, has been considering the value of TSDSs and how the federal agencies can support the development and use of these documents. The first step has been to try to create a generic format that incorporates the best aspects of the existing TSDS templates. A subcommittee has been tasked with suggesting a generic format. They met in June 2000 at OSHA headquarters in Washington, D.C. The first draft of the generic format was presented to the full EPA/Labor task force on July 12, 2000.

INTENDED USES OF TSDSs

As originally conceived in 1994 by Dr. Matthew Fitzgerald, TSDSs would be used by workers who operate and maintain the technology, safety and health professionals charged with protecting personnel on hazardous waste sites, and regulators who must write permits for technologies on state Superfund sites. Given that the technologies are intended for cleaning up hazardous waste, the TSDS was seen as valuable in complying with regulatory requirements. For instance, the TSDS can be incorporated into a site's U.S. OSHA-required Hazard Communication Program or Hazardous Waste Operations and Emergency Response (HAZWOPER) informational program. Like an MSDS, the TSDS should be readily accessible to all workers in proximity to the technology. In addition, the TSDS can be used to improve the site-specific elements of required HAZWOPER training (both initial and refresher courses). The potential training value of TSDSs is great, particularly in the absence of any other standardized tool for disseminating this information.

Most of the documentation that is created for innovative environmental remediation technologies is oriented towards either engineering or sales. There is little available for workers. The TSDS was conceived as a short, focused document for workers. Given the exceptionally high rates of injuries during maintenance work - particularly during emergency maintenance - TSDSs were envisioned as a tool to prevent injuries during maintenance work. Seemingly mundane aspects like maintenance practices can make an enormous difference with new technologies. Taylor found specific accident rates for similar equipment varied by a factor of over 100, due to differences in maintenance practices and routine inspections. (6)

FORMAT OF TSDSs

This innovative instrument relies on the familiarity of an old format - Material Safety Data Sheets - to impart critical information about the risks posed by new technologies. MSDSs have become an established tool for informing workers about the chemical hazards to which they are exposed. Over four billion MSDSs are in circulation in the United States. (7) MSDSs existed prior to OSHA's promulgation of the Hazard Communication Standard (29 CFR 1910.1200) in November 1983, but the standard made MSDSs the central requirement and recommended an eight-part format for the document. The American National Standards Institute (ANSI) recently published a consensus standard (ANSI Z400.1) that contains 16 sections. This standard has become increasingly popular in the United States, Canada, and Europe and figures centrally in the international effort to harmonize hazard communication standards. There, unfortunately, has been extremely limited testing of the ANSI format for readability and comprehensibility and one study found that the new ANSI format ranked last in comprehensibility behind the old OSHA format and a format called the International Chemical Safety Card. (8) The intent is to use the lessons learned by researchers and practitioners from creating MSDSs for 19 years and improve the format of TSDSs accordingly.

Every organization that has created a TSDS has used a different format. There is much overlap, but each format has unique sections and approaches. The OENHP has followed the original format proposed by Dr. Fitzgerald and has found that the format sufficiently robust to handle technologies as disparate as robotic asbestos strippers and carbon dioxide floor blasting systems. OSHA has included much more regulatory information in their format, creating documents only for technologies commonly found on large hazardous waste sites. Indiana University of Pennsylvania (IUP) has created a tool written expressly for workers and a separate one for state regulators, which includes more detailed operational information for decisionmakers who must determine whether to issue a demonstration permit. This approach by IUP avoids the one-size-fits-all problem for which

MSDSs have been roundly criticized. Safety and health professionals in the Navy have developed a two-part approach: they begin with a checklist and then extract key information from it for a concise and focused document the Navy called a Technical Safety Data Sheet. Both the original worksheet and the TSDS are posted on a Navy Internet site where maintenance staff from around the world can get access.

A group of experts reached a consensus at a 1996 National Technical Workshop (9) that the following sections should be contained in the TSDS:

- Section 1: Technology Identity
- Section 2: Process Description
- Section 3: Process Diagram or Photograph
- Section 4: Contaminants and the Medium
- Section 5: Associated Safety Hazards
- Section 6: Associated Health Hazards
- Section 7: Phase Analysis
- Section 8: Health and Safety Plan Required Elements
- Section 9: Comments and Special Considerations
- Section 10: Case Studies

KEY INFORMATION IN TSDSs

There has been unanimous agreement by workshop participants that TSDSs should never take the place of a formal system safety analysis like a Job Hazard Analysis or Failure Modes and Effect Analysis. Rather, the information suggested below should be collected by a team specifically chosen for the technology. All of the organizations presently creating TSDSs use teams of safety and health experts along with workers who will operate the equipment to perform a formal safety analysis. The information generated from that exercise is then carefully reviewed for inclusion in a TSDS.

Technology Identity

This section should identify the technology and list any alternative names that the technology is known by, as well as the manufacturer's name and address. Key information and emergency contacts should be included. The name and address of the originator of the TSDS needs to be included because as additional information becomes available, it needs to be relayed to the originator for inclusion in the next revision of the TSDS.

Process Description, Diagrams, and Photographs

The basic operation is described in this section with as much support from diagrams and photographs as possible. This section is not meant to be a set of standard operating procedures but just sufficient detail so workers can understand how the technology works.

Contaminants and Medium

Environmental technologies are designed to handle specific contaminants such as petroleum products or radioactive wastes. The hazards associated with those contaminants need to be clearly described in the TSDS. The medium that is being cleaned should also be described. The following questions should be answered. Does the technology clean up soils or groundwater? Does it operate in the medium such as an in situ groundwater cleaning unit or does the contaminant have to be brought to the technology? What happens to residues generated by the process? Are the agents used to treat the contaminants of greater risk to the site workers than the contaminants. Clearly, this was the case in the DOE explosion where the use of sodium permanganate posed greater risk to the site workers than the trichloroethene in the groundwater.

Associated Safety Hazards

The consensus of the several workshops held that safety hazards should be considered before health hazards on a TSDS because the risks are usually much greater than from health hazards. This approach was borne out by a study of 1,848 incidents reported by a large hazardous waste abatement firm over 6.5 years. Over 75 percent of the injuries and illnesses were due to mechanical agents and only 10 percent were due to chemical exposures. (10)

The following safety hazards must be considered for each Technology Safety Data Sheet:

Electrical	Fire & explosion
Confined space entry	Mechanical hazards
Pressure hazards	Tripping and falling
Ladders and platforms	Moving vehicle
Buried utilities, drums, & tanks	Protruding objects
Gas cylinders	Trenching & excavations
Overhead lifts	Overhead hazards

Repeated workshop findings have supported the original supposition that it is important to rate the risk associated with each of the hazards that are identified. The OENHP has used a simple four level rating. See Table I.

It is important to note that the TSDSs created by Indiana University of Pennsylvania for the U.S. Department of Defense follow the classic risk rating approach of considering risk the product of the probability of an unwanted event and the severity of that event if it occurs. This approach has been used by the military for years, as codified in Military Standard 882B which defines risk as "an expression of the possibility of a mishap in terms of hazard severity and hazard probability." (11)

Associated Health Hazards

All health hazards associated with the technology should be listed and ranked in terms of relative risk and severity, using the same rating. The same rating system as described above for safety hazards is used for health hazards. The following hazards are always considered:

Inhalation hazards

TABLE I
OENHP Hazard Rating

Hazard Rating	Description
1	Hazard may be present but not expected over background levels
2	Some level of hazard above background level
3	High hazard level
4	Potential for imminent danger to life and health

Skin absorption
Heat stress
Noise
Nonionizing radiation
Ionizing radiation
Cold stress
Ergonomic hazards

Phase Analysis

A hazardous waste site is similar to a construction site in that it is constantly changing, moving from initial characterization, through remediation, and ultimately to closure. Phase analysis is routinely used in construction to identify new hazards before beginning a new phase. (12) Each phase of a remediation technology at a site imposes its own hazards, and therefore, must be taken into consideration. It is quite possible that the operational phase is the least hazardous. Transporting the equipment to the site exposes workers to hazards that are very different from those of constructing the unit. For example, hauling the hazardous waste incinerator to the Bridgeport, New Jersey site required 30 flatbed trucks.(4) Currently, transportation accidents are the number one cause of occupational fatalities in America. (13) Maintenance, particularly emergency repairs pose particularly high risks. The developer should consider each phase of the use of the technology and identify hazards.

Health and Safety Plan Required Elements

This section identifies specific OSHA regulatory requirements that need to be addressed and information that must be included in the site Health and Safety Plan (HASP). The latter facilitates the work of the site safety and health professional who must maintain the HASP for the hazardous waste site where the new technology will be tried.

FUTURE POLICY INITIATIVES AND RESEARCH

The Department of Energy is now evaluating the effectiveness of the current TSDS format by conducting four pilot tests with users of the technologies at several of the nuclear weapons plants. The effort is aimed at getting feedback on how well TSDSs fit into the Department's demonstrably successful safety strategy called Integrated Safety Management. DOE is also interested in how TSDSs can be linked to the recent technical report from the American National Standards Institute called, ANSI B11.TR3:2000, "Risk assessment and risk reduction reduction – a guide to estimate, evaluate and reduce risks associated with machine tools. (14) The technical report recommends that a hazard assessment be performed on new technologies and that risks be reduced to a "tolerable" state. The information generated by following the ANSI approach correlates well with what is reported in the TSDS (see Table II). Discussions will be held with the B11 committee to officially explore the value of connecting the two. Similarly, DOE has initiated discussions with the European Community about the CE Marking and plans to continue these efforts.

REFERENCES

1. OAKLEY, D. & BOYD, G. (1999, Sept.). "Worker Safety and Health through the Deployment o Environmental Cleanup Technologies. Presented at the Fifth International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Prague 2000, Sept. 12-14, 2000.
2. U.S. Department of Energy. (2000) "Type B Accident Investigation: Injury Resulting from Violent Exothermic Chemical Reaction at X-701B Site Portsmouth Gaseous Diffusion Plant". Oak Ridge Operations.
3. Environmental Management Advisory Board, Worker Health and Safety Committee (2000, April 13). "Preliminary report: Consideration of occupational safety and health in the EM-OST technology development program." 7.
4. National Institute of Environmental Health Sciences and the U.S. Department of Energy, (1996, Oct.) "Anticipating Occupational Hazards of Cleanup Technologies: Remembering the Worker: Guidance Document and Technical Workshop Report, Cooperative Agreement #DE-FC21-95MC32260.
5. U.S. Department of Energy, (2001, April 30). "Assessing the Full Costs of New Remediation Technologies: Guidelines for Identifying Occupational Safety and Health Costs for Environmental Remediation Technologies," Report of a National Technical Workshop, held in Beckley, WV, October 23-25, 2000, DOE Cooperative Agreement DE-FC21-95MC32260.
6. TAYLOR, J.R. (1994). "Risk analysis for process plant, pipelines, and transport." London: Chapman & Hall. 411
7. PHILLIPS, C. (1998). "An evaluation of the comprehensibility of three MSDS formats." (Doctoral dissertation. University of Tennessee, 1990).
8. PHILLIPS, C.C, WALLACE, B.C., HAMILTON, C.B., PURSLEY, R.T., PETTY, G.C., & BAYNE, C.K. (1999).

TABLE II
Comparison of ANSI Recommendations and TSDS Format

ANSI Recommended Steps	Corresponding TSDS section
Determine limits of the machine or system	Process description
Identify all tasks and corresponding hazards	Associated safety and health hazards
Estimate the risk	Risk rating
Reduce the risk	Phase analysis
Document the efforts of supplier and users	Health and Safety Plan elements and CE Marking Technical File.

The efficacy of material safety data sheets and worker acceptability. Journal of Safety Research, 30, 2, 113.

9. U.S. Department of Energy and National Institute for Environmental Health Sciences. (1996). National Technical Workshop. "Anticipating Occupational Hazards of Cleanup Technologies: Remembering the Worker. Guidance Document and Technical Workshop Report".
10. AKBAR-KHANZADEH, F. & REJENT, G.M. (1999, Sept/Oct.) "Incident Trends for a Hazardous Waste Cleanup Company," American Industrial Hygiene Journal, Vol.60: 666-672.
11. U.S. Department of Defense (1984, March 30) "MIL-STD-882B System Safety Program Requirements," AMSC Number F3329 FSC SAFT, Washington DC 20301.
12. U.S. Department of Labor (1993) "Managing Worker Safety and Health," Office of Cooperative Programs, OSHA. 7-16.
13. National Safety Council (1999) "1999 Injury Facts," Itasca, IL: National Safety Council Press.
14. American National Standards Institute (2000) ANSI B11.TR3: 2000, ANSI Technical Report for Machine Tools, "Risk assessment and risk reduction – a guide to estimate, evaluate, and reduce risks associated with machine tools," Secretariat: The Association for Manufacturing Technology, McClean, VA.